MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

Earth Science Data and Information System (ESDIS)

Level 1 Product Generation System (LPGS)

Functional and Performance Requirements Specification

February 1997

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Preface

The Level 1 Product Generation System (LPGS), in conjunction with the Mission to Planet Earth (MTPE) Earth Observing System (EOS) Ground System (EGS), will provide both radiometrically and geometrically corrected (Level 1R and Level 1G) data generation support to the Landsat 7 program. This document specifies requirements to be met by the LPGS, which are in accordance with the *Earth Science Data Information and System (ESDIS) Mission-Specific Requirements Document for the Landsat 7 Mission Level 1 Processing*.

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Abstract

This Functional and Performance Requirements Specification (F&PRS) contains detailed Level 3 requirements for the LPGS. The LPGS detailed requirements are based on an analysis of the Level 2 functional and performance requirements contained in the *Earth Science Data and Information System (ESDIS) Mission-Specific Requirements Document for the Landsat 7 Mission Level 1 Processing* and found to be allocated to the LPGS. Once baselined at the system requirements review (SRR), this F&PRS will serve as the primary source requirements document for the design and implementation of the LPGS. The baselined LPGS F&PRS will be maintained and controlled by the Goddard Space Flight Center (GSFC) Data Processing Systems Branch (Code 514).

Also included in this specification are a requirements verification matrix and traceability matrices tracing the LPGS requirements to the *ESDIS Mission-Specific Requirements Document for the Landsat 7 Mission Level 1 Processing* and the *LPGS Operations Concept.*

Keywords: *Level 1 Product Generation System (LPGS)*

Level 1 Radiometrically corrected digital image (L1R)

Level 1 Geometrically corrected digital image (L1G)
Landsat 7
ECS
ESDIS

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Appendix C—Glossary

Section 1—Introduction

1.1 Scope

This document contains the detailed Level 3 functional and performance requirements for the Level 1 Product Generation System (LPGS). These requirements are traceable to the *ESDIS Mission Specific Requirements Document for the Landsat 7 Mission Level 1 Processing* (January 15, 1997) and the *LPGS Operations Concept* (February 1997).

1.2 LPGS Overview

The LPGS is a source of Enhanced Thematic Mapper Plus (ETM+) Level 1 (L1) data within the ESDIS Ground System (EGS). The EGS is a collection of ground support elements for the Earth Observing System (EOS) and includes EOS Data and Information System (EOSDIS), institutional support elements, affiliated and international partner data centers, international partner instrument control and operations centers, and other sources of data. The LPGS is located at the Earth Resources Observation System (EROS) Data Center (EDC) Distributed Active Archive Center (DAAC) and provides ETM+ L1 digital image generation and transfer services on a demand basis. The LPGS receives L1 digital image generation requests and distributes generated L1 digital images to customers through the ECS at the EDC DAAC on a first in-first out (FIFO) basis.

The LPGS produces L1 data images in electronic format corresponding to a Worldwide Reference System (WRS) scene, floating scene center, or partial ETM+ subintervals of up to three WRS scene equivalents based on customer requests. The LPGS is capable of producing a daily volume equivalent to at least 25 WRS scenes of L1 radiometrically corrected and geometrically corrected images in any combination. The LPGS can create digital images projected to different coordinate reference systems, for any combination of the eight spectral channels collected by the ETM+ instrument, or in different output formats according to other options specified in the customer's request. The Level 0R (L0R) data are requested from the EDC DAAC, and appended calibration parameter, payload correction data (PCD), and mirror scan correction data (MSCD) files are applied by the LPGS in producing L1 digital images.

The digital images created by the LPGS are provided, along with processing status, quality information (metadata), associated calibration parameter file, PCD, MSCD, and calibration data to the EOSDIS Core System (ECS), which distributes the entire L1 product to the customer.

Section 2—Documentation

2.1 Applicable Documents

The information in the following documents was used to develop the LPGS functional and performance requirements specification.

1. NASA GSFC, 209-CD-013-003, *Interface Control Document Between the EOSDIS Core System (ECS) and the Landsat 7 System*, March 1996

2. 194-207-SE1-001, *System Design Specification for the ECS Project*, June 1994

3. *Landsat 7 L1 Product Generation System (LPGS) Project Management Plan*, Draft, May 1996

4. *Landsat 7 System and Operations Concept*, October 13, 1994

5. NASA GSFC/MO&DSD, *Level 1 Product Generation System (LPGS) Operations Concept*, February 1997

6. NASA GSFC, 505-41-13, *IRD Between ECS and the Landsat 7 System*, July 1995

7. NASA GSFC, *ESDIS Mission-Specific Requirements Document for the Landsat 7 Mission L1 Processing*, January 15, 1997

8. 430-15-01-001-0, *Landsat 7 System IAS Element Specification*, Baseline, September 17, 1996

9. 9NHB 2410.9A, *NASA Automated Information Security Handbook*, June 1993

10. 505-10-23, *ESDIS Security Policy and Guidelines*, March 1996

2.2 Reference Documents

The following documents were used for background information.

1. United States Geological Survey (USGS)/National Oceanic and Atmospheric Administration (NOAA), *Index to Landsat Worldwide Reference System (WRS) Landsats 1, 2, 3, and 4,* 1982

2. MO&DSD, *Mission Operations Concept for the Landsat 7 Ground System,* Draft, June 1995

3. NASA/GSFC, *Landsat 7 Processing System (LPS) Operations Concept*, April 15, 1996

2.3 Definitions

The following terms, as defined in this section, are commonly used throughout this document to describe LPGS processing:

Level 0R (L0R) digital image—Spatially reformatted, demultiplexed, and unrectified subinterval data.

Level 0R (L0R) product The L0R digital image plus radiometric calibration, attitude, and ephemeris data, consisting of the following files:

- L0R digital image

- Internal calibrator (IC) data   Calibration data file containing all the calibration data received on a major frame basis for a given subinterval

- Mirror scan correction data (MSCD)   The scan direction and error information for a given subinterval

- Payload correction data (PCD) Information on spacecraft attitude and ephemeris, including quality indicators for each subinterval

- Metadata   Descriptive information about the L1 digital image, names of appended files associated with the image, and quality and accounting information

- Calibration parameter file (CPF)   A formatted file containing gains, biases, and   offsets for the instrument and detectors

Level 1R (L1R) digital image—Radiometrically corrected but not geometrically resampled. Image size can be from .25 to 3 WRS scene equivalents. Can be WRS-based or have a floating scene center but is restricted to one orbital path and must be generated from the same Level 0 acquisition interval.

Level 1G (L1G) digital image—Radiometrically corrected and resampled for geometric correction and registration to geographic map projections. Can be WRS-based or have a floating scene center but is restricted to one orbital path and must be generated from the same Level 0 acquisition interval.

Level 1R (L1R) product—L1 product packaged by LPGS and distributed by the ECS to the customer includes for all requested bands: L1R image data, metadata including processing quality information, IC data file, CPF, combined PCD file, combined MSCD file, and geolocation table in hierarchical data format (HDF).

Level 1G (L1G) product—L1 product packaged by LPGS and distributed by the ECS to the customer includes for all requested bands: Fast Argonne System for Transport (FAST) or Geographic Taf(ged) Image File Format (GeoTIFF) format L1G image and associated data accommodated by the format; HDF format L1G image, metadata, CPF, and geolocation table.

Production quality assessment—Ancillary information collected and generated during L1 processing; provides information on the certainty with which corrections were made to images; nominally appended as a file to the L1 product.

Interval—The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument.

Subinterval—Segment of time corresponding to a portion of an observation within a single Landsat 7 contact period.

Worldwide Reference System (WRS) scene—Digital image that covers an area equivalent to one of the 57,784 scene centers (233 paths x 248 rows areas) defined by the WRS structure.

Section 3—LPGS Functional Requirements

3.1 System Level Requirements

3.1.1 The LPGS shall nominally generate Level 1 digital images on a first ordered, first processed (FIFO) basis.

3.1.2 The LPGS shall provide the capability to move a Level 1 image processing work order within the FIFO queues according to operator direction.

3.1.3 Deleted

3.1.4 Deleted

3.1.5 The LPGS shall provide the capability to generate and report LPGS error messages.

3.1.6 The LPGS shall provide an interactive capability to facilitate detection and correction of abnormal system conditions.

3.1.7 The LPGS shall provide the capability to isolate system faults.

3.1.8 The LPGS shall provide the capability to recover from system faults.

3.1.9 The LPGS shall provide the capability to test LPGS functions and external interfaces.

3.1.10 The LPGS shall provide the capability to support attended operations 24 hours per day, 7 days per week, on a continuous basis.

3.1.11 The LPGS shall provide the capability to support unattended, automatic processing 16 hours per day, 7 days per week, on a continuous basis.

3.1.12 The LPGS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.

3.1.13 The LPGS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.

3.1.14 The LPGS shall provide the capability to support end-to-end testing of Level 1 processing functions.

3.1.15 The LPGS shall provide the capability to control LPGS operations.

3.1.16 The LPGS shall provide the capability to monitor LPGS operations.

3.1.17 The LPGS shall provide the capability to reconfigure LPGS system resources.

3.1.18 The LPGS shall provide the capability to support software upgrades while supporting normal operations.

3.1.19 The LPGS shall be capable of making all software and databases used in operations accessible to ECS for archiving.

3.1.20 The LPGS design shall be scaleable to allow for future growth in processing capability.

3.1.21 The LPGS shall be able to generate Level 1 digital images corresponding to either heritage Worldwide Reference System (WRS) scenes or to a partial ETM+ subinterval up to an area equivalent to three WRS scenes.

3.1.22 The LPGS shall be capable of recovering from failures and aborts in a controlled manner.

3.2 External Interface Requirements

3.2.1 The LPGS shall interface with the ECS to receive:

    3.2.1.1 L0R files (includes associated PCD, MSCD, and CPF)

    3.2.1.2 Level 1 image processing requests

    3.2.1.3 Data availability notification

    3.2.1.4 Production status requests

    3.2.1.5 Product cancellation requests

    3.2.1.6 Product problem report (Trouble Ticket)

3.2.2 The LPGS shall interface with the ECS to coordinate the transfer of the following:

    3.2.2.1 LPGS L1 digital images

    3.2.2.2 Processing status

    3.2.2.3 Production quality and accounting information

    3.2.2.4 L1 processing statistics

    3.2.2.5 L1 metadata

    3.2.2.6 PCD file (consensus)

    3.2.2.7 MSCD file (consensus)

    3.2.2.8 IC data file

    3.2.2.9 CPF

    3.2.2.10 Geolocation table

3.2.3 The LPGS shall interface with the Image Assessment System (IAS) to provide Level 1 radiometric characterization data.

3.2.4 The LPGS shall interface with the Data Handling Facility (DHF) to provide Level 1 processing anomaly reports.

3.3 Functional Requirements

3.3.1 Retrieve L0R Files

3.3.1.1 The LPGS shall provide the capability to receive L0R data inputs from the ECS. This data shall include the following items:

3.3.1.1.1 Level 1 image processing request that includes the following:

a. Selected coordinate reference system for map projection

b. Requested orientation (nominal path or north up)

c. Variable grid cell size selection

d. Output format selection

e. Resampling filter

f. Selected band(s)

g. Selected scene or subinterval identification

h. L1R or L1G image processing selection

I. Geographic area

j. WRS (path/row) scene identifier

k. Internal calibrator (IC) or Calibration Parameter File (CPF) (default = CPF)

3.3.1.1.2 Data availability notification specifying the location of associated L0R product files ready for transfer

3.3.1.1.3 L0R product files (includes L0R image data, PCD, MSCD and associated Calibration files [internal calibrator and calibration parameter files])

3.3.1.1.4 Production status request

3.3.1.1.5 Product cancellation request

3.3.1.1.6 Product problem report (Trouble Ticket)

3.3.1.2 The LPGS shall provide the capability to create and send L0R product requests to the ECS.

3.3.1.3 The LPGS shall coordinate resolution of data transfer problems with any L0R product file with ECS.

3.3.1.3.1 The LPGS shall be able to detect data transfer problems.

3.3.1.3.2 The LPGS shall be able to reorder data.

3.3.2 Generate L1R Digital Images

The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L0R Earth image data file to produce radiometrically corrected L1R digital images.

3.3.2.1 The LPGS shall be able to extract and process attitude and ephemeris data from the L0R Payload Correction Data (PCD) files.

3.3.2.2 The LPGS shall be able to extract parameters from the L0R internal calibrator or calibration parameter file for use in L1R and L1G processing.

3.3.2.3 The LPGS shall be able to generate gains and biases from either the internal calibrator data or from the calibration parameter file. The default shall be the calibration parameter file.

3.3.2.4 The LPGS shall be able to extract and process mirror scan correction coefficients from the L0R MSCD file to determine scan line quality.

3.3.2.5 The LPGS shall be capable of detecting the following image artifacts:

3.3.2.5.1 Striping

3.3.2.5.2 Banding

3.3.2.5.3 Coherent noise

3.3.2.5.4 Deleted

3.3.2.5.5 Scan correlated shift

3.3.2.5.6 Saturated detectors

3.3.2.5.7 Dropped scan lines

3.3.2.6 The LPGS shall be capable of characterizing the following image artifacts:

3.3.2.6.1 Striping

3.3.2.6.2 Banding

3.3.2.6.3 Coherent noise

3.3.2.6.4 Deleted

3.3.2.6.5 Deleted

3.3.2.6.6 Saturated detectors

3.3.2.6.7 Dropped scan lines

3.3.2.7 The LPGS shall be capable of applying compensation for the following image artifacts:

3.3.2.7.1 Striping

3.3.2.7.2 Banding

3.3.2.7.3 Coherent noise

3.3.2.7.4 Memory effect

3.3.2.7.5 Scan correlated shift

3.3.2.7.6 Inoperable detectors

3.3.2.7.7 Saturated detectors

3.3.2.7.8 Dropped scan lines

3.3.2.8 The LPGS shall be capable of applying compensation for gain changes within a requested Level 1 scene or subinterval as identified in the Level 0R metadata.

3.3.2.9 The LPGS shall be capable of producing L1R data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.

3.3.2.10 The LPGS shall be able to produce L1R digital images for any combination of the eight spectral channels.

3.3.2.11 The LPGS shall assemble and append to the L1R digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1R digital image. The complete L1R digital image package contains the following data elements as a minimum:

3.3.2.11.1 Level 1R digital image (all requested bands)

3.3.2.11.2 Level 1 metadata file

3.3.2.11.3 Deleted

3.3.3 Generate L1G Digital Images

The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L1R Earth image data files to produce systematically corrected L1G digital images.

3.3.3.1 The LPGS shall have the capability to resample L1R digital images and apply the following map projections:

3.3.3.1.1 Space Oblique Mercator

3.3.3.1.2 Universal Transverse Mercator (UTM)

3.3.3.1.3 Lambert Conformal Conic

3.3.3.1.4 Transverse Mercator

3.3.3.1.5 Oblique Mercator

3.3.3.1.6 Polyconic

3.3.3.1.7 Polar Stereographic

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3.3.3.2 The LPGS shall support the following compensation resampling methods:

  3.3.3.2.1 Nearest neighbor

  3.3.3.2.2 Cubic convolution

  3.3.3.2.3 Modulation Transfer Function (MTF)

3.3.3.3 The LPGS shall have the capability to produce L1G digital images with the following grid cell characteristics:

  3.3.3.3.1 The grid cell size is variable from 15 M to 60 M in .001 M increments.

  3.3.3.3.2 The grid cell size is independently variable between spectral bands.

3.3.3.4 The LPGS shall produce L1G digital images that are spatially continuous between contiguous partial subintervals or WRS scenes

3.3.3.5 The LPGS shall have the capability to generate L1G digital images oriented by the following:

  3.3.3.5.1 Nominal path

  3.3.3.5.2 North up

3.3.3.6 The LPGS shall be capable of producing L1G data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.

3.3.3.7 The LPGS shall be able to produce L1G digital images for any combination of the eight spectral channels.

3.3.3.8 The LPGS shall assemble and append to the L1G digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1G digital image. The complete L1G digital image package contains the following data elements as a minimum:

  3.3.3.8.1 Level 1G digital image (all requested bands)

  3.3.3.8.2 Level 1 metadata file

  3.3.3.8.3 Deleted

3.3.4 Generate Level 1 Metadata File

3.3.4.1 The LPGS shall generate ancillary L1R digital image data that describes the contents, processing parameters, and quality indicators of the L1R digital image.

3.3.4.2 The LPGS shall generate ancillary L1G digital image data that describes the contents, processing parameters, and quality indicators of the L1G digital image.

3.3.4.3 The LPGS shall generate and append processing summary indicators specifying the algorithms applied to the Level 1 digital images.

3.3.5 Assess Level 1 Digital Image Quality

3.3.5.1 The LPGS shall support automatic assessment of Level 1 digital image quality.

3.3.5.2 The LPGS shall be able to optionally display any single band of the L1R digital image for visual quality assessment.

3.3.5.3 The LPGS shall be able to optionally display any single band of the L1G digital image for visual quality assessment.

3.3.5.4 The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1R digital image for visual quality assessment

3.3.5.5 The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1G digital image for visual quality assessment.

3.3.6 Transfer Level 1 File(s)

3.3.6.1 The LPGS shall be able to output Level 1 digital images in the following formats:

  3.3.6.1.1 HDF-EOS (L1R and L1G)

  3.3.6.1.2 EOSAT FAST (L1G only)

  3.3.6.1.3 GeoTIFF (L1G only)

3.3.6.2 The LPGS shall transfer L1 files to ECS per the ECS to LPGS ICD.

3.3.6.3 The LPGS shall provide the capability to display LPGS Level 1 file transfer summary upon operator request.

3.3.6.4 The LPGS shall be able to detect files which have been successfully transferred.

3.3.6.5 The LPGS shall be able to mark successfully transferred files as candidates for deletion from LPGS temporary storage.

3.3.7 Data Storage

3.3.7.1 The LPGS shall be able to provide temporary online storage for the equivalent of 3 days of completed products.

3.3.7.2 The LPGS shall be able retransmit files located in temporary storage.

3.3.7.3 The LPGS shall be able to store Level 1 processing information online for 90 days.

3.3.7.4 The LPGS shall be able to transfer Level 1 processing information to offline storage after 90 days.

3.3.7.5 The LPGS shall be able to recover, display, and print Level 1 processing information located on offline storage for the life of the mission.

3.3.8 Control LPGS Operations

3.3.8.1 The LPGS shall allow the operator to select thresholds for statistics and errors reported by the LPGS.

3.3.8.2 The LPGS shall automatically generate messages and alarms to alert the operator of LPGS results and errors exceeding operator-selected thresholds.

3.3.8.3 The LPGS shall generate intermediate processing summaries on a periodic basis according to operator specification.

3.3.8.4 The LPGS shall provide an option to display Level 1 digital image quality status and statistics at operator request.

3.3.8.5 The LPGS shall provide an option to print Level 1 digital image quality status and statistics at operator request.

3.3.8.6 The LPGS shall provide the capability to manually override the LPGS automated processing functions.

3.3.8.7 The LPGS shall provide the manual capability to cancel Level 1 processing prior to completion of digital image generation.

3.3.8.8 The LPGS shall be able to display and print trouble tickets received from ECS.

Section 4—LPGS Performance Requirements

4.1 Performance Requirements

4.1.1 The LPGS shall be capable of processing a volume of data equivalent to 28 (accounts for 10 percent LPGS internal reprocessing) standard L0R WRS scenes to Level 1 digital images each day.

4.1.2 The LPGS shall contribute no greater than .7 percent uncertainty to absolute radiometric accuracy during the generation of L1R and L1G digital images.

4.1.3 The LPGS shall contribute circular errors no greater than 1.8 m, 1 sigma, in the production of systematically corrected L1G digital images.

4.1.4 The LPGS shall provide at least 110 percent of the processing throughput capability required to satisfy the worst case processor loading.

4.1.5 The LPGS shall provide at least 125 percent of the random access memory capacity required to satisfy the worst case memory loading.

4.1.6 The LPGS shall provide at least 125 percent of the peripheral storage capacity required to satisfy the worst case peripheral storage loading.

4.1.7 Deleted

4.1.8 The LPGS shall produce Level 1G products that are accurate to within 250 meters cross track and 250 meters along track using geometric calibration information generated by IAS and contained in the associated calibration parameter file.

4.2 External Interface Performance Requirements

4.2.1 The LPGS shall be able to ingest from ECS a data volume equivalent to three WRS scenes worth of standard L0R data for each Level 1 digital image request.

4.2.2 The LPGS shall have the capability to support the transfer to ECS of the equivalent of a minimum of 25 WRS sized Level 1 digital images per day.

4.2.3 The LPGS-ECS interface shall provide the capability to transfer to the ECS at least 33 Gbytes of Level 1 output files per day.

4.3 Reliability, Maintainability, and Availability

4.3.1 The LPGS shall provide an operational availability of .96 (TBR).

4.3.2 The LPGS shall support a mean time to restore (MTTR) capability of 4 hours (TBR).

4.4 Security

4.4.1 The LPGS shall provide system, network, and operations security according to the ESDIS security policy (Applicable Document 10) and the NASA AIS Handbook (Applicable Document 9).

Appendix A—Traceability Matrixes

The following tables provide traceability of the LPGS requirements contained in the LPGS F&PS to the LPGS requirements contained in the *ESDIS Mission-Specific Requirements Document for Landsat 7 Level 1 Processing Requirements* (January 15, 1997)

LPGS F&PS Requirement	Level 1 Product Generation System F&PS Requirement Summary	ESDIS Requirement
3.1	**System Level Requirements**	
3.1.1	Generate Level 1 digital images on a first ordered, first processed (FIFO) basis	3.1.1.g
3.1.2	Provide the capability to rearrange FIFO Level 1 image processing queues according to operator direction	Derived - Ops Con
3.1.3	Deleted	
3.1.4	Deleted	
3.1.5	Provide the capability to generate and report LPGS error messages	3.1.6.b
3.1.6	Provide an interactive capability to facilitate detection and correction of abnormal system conditions	3.1.6.b
3.1.7	Provide the capability to isolate system faults	3.1.6.b
3.1.8	Provide the capability to recover from system faults	3.1.6.b
3.1.9	Provide the capability to test LPGS functions and external interfaces	3.1.7.b
3.1.10	Provide the capability to support attended operations 24 hrs per day, 7 days per wk, on a continuous basis	Derived - Ops Con
3.1.11	Provide the capability to support unattended, automatic processing 16 hrs per day, 7 days per wk, on a continuous basis	Derived - Ops Con
3.1.12	Provide the capability to support Landsat 7 operations for a minimum mission life of 5 years	3.1.6.d
3.1.13	Provide capability to execute diagnostic tests for verifying proper operation of system capabilities and components	3.1.7.c
3.1.14	Provide the capability to support end-to-end testing of Level 1 processing functions	3.1.7.b 3.1.7.c
3.1.15	Provide the capability to control LPGS operations	3.1.2.o
3.1.16	Provide the capability to monitor LPGS operations	3.1.2.o
3.1.17	Provide the capability to reconfigure LPGS system resources	3.1.2.o
3.1.18	Provide the capability to support software upgrades while supporting normal operations	3.1.7.a
3.1.19	Make all software and databases used in operations accessible to ECS for archiving	3.1.1.e
3.1.20	Design shall be scaleable to allow for future growth in processing capability	3.1.6.e
3.1.21	Generate Level 1 digital images corresponding to either heritage Worldwide Reference System (WRS) scenes or to a partial ETM+ subinterval up to an area equivalent to three WRS scenes	3.1.2.b 3.1.2.s
3.1.22	Recover from failures and aborts in a controlled manner	Derived - Ops Con
3.2	**External Interface Requirements**	
3.2.1	Interface with ECS to receive L0R files, processing	3.1.2.i

LPGS F&PS Requirement	Level 1 Product Generation System F&PS Requirement Summary	ESDIS Requirement
	requests, cancellation requests, data availability notices, status requests, and problem reports	3.1.8.a
3.2.2	Interface with ECS to coordinate the transfer of L1 digital images, processing status, processing statistics, and metadata	3.1.8.a
3.2.3	Interface with the IAS to provide L1 characterization data	3.1.8.a 3.1.4.d
3.2.4	Interface with the DHF to provide Level 1 processing anomaly reports	3.1.8.a
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3.3.2	Generate L1R digital images	3.1.1.b
3.3.2.1	Process payload correction data	3.1.2.o
3.3.2.2	Process L0R calibration parameter file	3.1.2.o
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3.3.2.7	Apply compensation for detected and characterized image artifacts	3.1.2.a
3.3.2.8	Apply compensation for gain changes within a requested L1R image as identified in the L0R metadata	3.1.2.a
3.3.2.9	Produce L1R data for both ascending and descending portions of Landsat 7 orbit.	3.1.2.b
3.3.2.10	Produce L1R digital images for any combination of the eight spectral bands	3.1.2.b
3.3.2.11	Assemble and append metadata to the L1R digital images	3.1.2.q
3.3.3	Generate L1G Digital Images	3.1.1.b
3.3.3.1	Resample L1R digital images and apply any one of 7 map projections: Space Oblique Mercator, UTM, Lambert Conformal Conic, Transverse Mercator, Oblique Mercator, Polyconic, and Polar Stereographic	3.1.2.f
3.3.3.2	Apply any one of three compensation resampling methods: nearest neighbor, cubic convolution, and MTF	3.1.2.h
3.3.3.3	Produce L1G digital images with variable grid cell sizes (15 M to 60 M at .001 M increments	3.1.2.e
3.3.3.4	Produce spatially continuos images between contiguous partial subintervals	3.1.2.c
3.3.3.5	Generate L1G digital images oriented to north-up or nominal WRS path	3.1.2.d
3.3.3.6	Produce L1G data for both ascending and descending portions of Landsat 7 orbit.	3.1.2.b
3.3.3.7	Produce L1R digital images for any combination of the eight spectral bands	3.1.2.b
3.3.3.8	Assemble and append metadata to the L1G digital images	3.1.2.q
3.3.4	Generate Level 1 metadata file	{Header}

LPGS F&PS Requirement	Level 1 Product Generation System F&PS Requirement Summary	ESDIS Requirement
3.3.4.1	Generate ancillary L1R digital image data that describes the contents, processing parameters, and quality indicators of the L1R digital image	3.1.2.q 3.1.2.r 3.1.4.b
3.3.4.2	Generate ancillary L1G digital image data that describes the contents, processing parameters, and quality indicators of the L1G digital image	3.1.2.q 3.1.2.r 3.1.4.b
3.3.4.3	Generate and append processing summary indicators specifying the algorithms employed in processing the Level 1 digital image	3.1.4.c
3.3.5	Assess Level 1 digital image quality	{Header}
3.3.5.1	Support automatic assessment of Level 1 digital image quality	3.1.2.o 3.1.2.p
3.3.5.2	Optionally display any single band of the L1R digital image for visual quality assessment	3.1.2.o 3.1.2.p
3.3.5.3	Optionally display any single band of the L1G digital image for visual quality assessment	3.1.2.o 3.1.2.p
3.3.5.4	The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1R digital image for visual quality assessment	3.1.2.o 3.1.2.p
3.3.5.5	Optionally print a color hard copy of the display of any band(s) of the L1G digital image for visual quality assessment	3.1.2.o 3.1.2.p
3.3.6	Transfer Level 1 files	{Header}
3.3.6.1	Output Level 1 image data files in HDF-EOS, GeoTIFF, and EOSAT-FAST formats	3.1.2.g
3.3.6.2	Transfer L1 files to ECS per ECS to LPGS ICD	3.1.8.a
3.3.6.3	Display Level 1 file transfer status to operator	3.1.6.b
3.3.6.4	Detect files which have been successfully transferred	3.1.6.b
3.3.6.5	Mark successfully transferred files for deletion	3.1.6.b
3.3.7	Data storage	{Header}
3.3.7.1	Temporarily store L1R and L1G completed products for 72 hours	3.1.3.a
3.3.7.2	Retransmit files located in temporary storage	3.1.3.b
3.3.7.3	Store Level 1 processing information online for 90 days	Derived - Ops Con
3.3.7.4	Transfer Level 1 processing information to offline storage after 90 days	Derived - Ops Con
3.3.7.5	Recover, display, and print Level 1 processing information located on offline storage for the life of the mission	Derived - Ops Con
3.3.8	Control LPGS operations	{Header}
3.3.8.1	Allow the operator to select thresholds for statistics and errors reported by the LPGS	3.1.6.b
3.3.8.2	Automatically generate messages and alarms to alert the operator of LPGS results and errors exceeding operator selected thresholds	3.1.6.b
3.3.8.3	Generate intermediate processing summaries on a periodic basis according to operator specification	3.1.6.b

LPGS F&PS Requirement	Level 1 Product Generation System F&PS Requirement Summary	ESDIS Requirement
3.3.8.4	Provide an option to display Level 1 digital image quality status and statistics at operator request	3.1.6.b
3.3.8.5	Provide an option to print Level 1 digital image quality status and statistics at operator request	3.1.6.b
3.3.8.6	Provide the capability to manually override the LPGS automated processing functions	3.1.6.b
3.3.8.7	Provide the manual capability to cancel Level 1 processing prior to completion of digital image generation	3.1.2.i
3.3.8.8	Display and print trouble tickets received from ECS	3.1.6.b
4.1	**Performance Requirements**	
4.1.1	Process a volume of data equivalent to 28 (accounts for 10% reprocessing) standard L0R WRS scenes to Level 1 digital images each day	3.1.1.a 3.1.6.a
4.1.2	Contribute no more than .7% uncertainty to absolute radiometric accuracy during the generation of L1R and 1G digital images	3.1.2.m 3.1.2.n
4.1.3	Contribute circular errors no greater than 1.8 m, 1 sigma, in the production of systematically corrected L1G digital images	3.1.2.m 3.1.2.n
4.1.4	Provide at least 110% of the processing throughput capability required to satisfy the worst case processor loading	Derived
4.1.5	Provide at least 125% of the random access memory capacity required to satisfy the worst case memory loading	Derived
4.1.6	Provide at least 125% of the peripheral storage capacity required to satisfy the worst case peripheral storage loading	Derived
4.1.7	Deleted	
4.1.8	Provide Level 1G products that are accurate within 250 meters cross track and 250 meters along track	3.1.2.m 3.1.2.n
4.2	**External Interface Requirements**	
4.2.1	Ingest from ECS a data volume equivalent to three WRS scenes worth of standard L0R data for each Level 1 digital image request	3.1.2.b
4.2.2	Support the transfer to ECS the equivalent of a minimum of 25 WRS sized digital images per day	3.1.1.a
4.2.3	Provide the capability to transfer to the ECS at least 33 Gbytes of Level 1 output files per day	3.1.1.a
4.3	**Reliability, Maintainability, and Availability(RMA) Requirements**	
4.3.1	Provide LPGS operational availability of .96 (TBR)	Derived
4.3.2	Provide MTTR of 4 hours (TBR)	Derived
4.4	**Security Requirements**	
4.4.1	Provide system, network, and operations security according to the ESDIS security guideline	3.1.1.h

ESDIS Requirement	ESDIS Requirement Text	LPGS F&PS Requirements
	General Requirements	
3.1.1.a	The EOSDIS shall provide the capability to generate at least 25 Level 1R or 1G equivalent WRS scene data products per day in any combination.	4.1.1
3.1.1.b	The Level 1R or 1G scene products generated by the EOSDIS shall be bound by the contents of the corresponding Level 0R scene product. (What is the limit on L0R scene product size?)	3.3.2 3.3.3
3.1.1.e	The EOSDIS shall store documentation (such as algorithm descriptions) and production process software for the Level 1R and 1G production process.	3.1.19
3.1.1.f	The EOSDIS shall make documentation and production process software available to users on request.	ECS
3.1.1.g	The EOSDIS shall generate Level 1 data products on demand based on submission of user orders.	3.1.1
3.1.1.h	The EOSDIS shall provide security according to the ESDIS security policy.	4.4.1
	Data Processing Requirements	
3.1.2.a	The EOSDIS shall provide the capability to compensate for systematically correctable artifacts during the production of the Level 1R and Level 1G digital image products.	3.3.2.5 3.3.2.6 3.3.2.7 3.3.2.8
3.1.2.b	The EOSDIS shall provide the capability to generate Level 1 data products corresponding to either heritage world-wide reference system (WRS) scenes or to a partial ETM+ subinterval up to an area equivalent to three WRS scenes.	3.1.21 3.3.2.9 3.3.2.10 3.3.3.6 3.3.3.7 4.2.1
3.1.2.c	The EOSDIS shall provide the capability to produce Level 1G data products that are spatially continuous between contiguous partial sub-intervals or WRS scenes	3.3.3.4
3.1.2.d	The EOSDIS shall provide the capability to generate Level 1G data products oriented to a nominal path or to North-up orientation.	3.3.3.5
3.1.2.e	The EOSDIS shall provide the capability to generate Level 1R or 1G data products with a variable grid cell size consistent with performance specifications provided by the Landsat 7 science office (see Reference TBD).	3.3.3.3
3.1.2.f	The EOSDIS shall provide the capability to generate Level 1R or 1G data products in coordinate reference systems for a minimum of seven (7) map projections.	3.3.3.1
3.1.2.g	The EOSDIS shall provide the capability to generate and distribute Level 1R or 1G data products in a minimum of three (3) output formats including HDF-EOS.	3.3.6.1
3.1.2.h	The EOSDIS shall provide the capability to generate Level 1G data products using a minimum of three (3) resampling methods as specified by the	3.3.3.2

ESDIS Requirement	ESDIS Requirement Text	LPGS F&PS Requirements
	Landsat 7 science office (see reference TBD).	
3.1.2.i	The EOSDIS shall accept order cancellations on previously ordered Level 1R and 1G data products.	3.2.1 3.3.8.7
3.1.2.j	The EOSDIS shall provide status on Level 1R and 1G data product orders to users.	ECS
3.1.2.k	The EOSDIS shall accept feedback from users on the quality of Level 1R and 1G data products.	ECS
3.1.2.l	The EOSDIS shall provide cost estimation for Level 1R and 1G data product orders.	ECS
3.1.2.m	The EOSDIS shall generate Level 1R data products consistent with performance specifications provided by the Landsat 7 science office (see Reference TBD).	4.1.2 4.1.3 4.1.8
3.1.2.n	The EOSDIS shall generate Level 1G data products consistent with performance specifications provided by the Landsat 7 science office. (see reference TBD)	4.1.2 4.1.3 4.1.8
3.1.2.o	The EOSDIS shall assure quality of the Level 1R and 1G data products consistent with performance specifications (see reference TBD).	3.3.2.1 3.3.2.2 3.3.2.3 3.3.2.4 3.3.2.5 3.3.2.6 3.3.2.7 3.2.2.8 3.3.5.1 3.3.5.2 3.3.5.3 3.3.5.4 3.3.5.5 3.1.15 3.1.16 3.1.17
3.1.2.p	The EOSDIS shall provide the capability to inspect, including visual inspection, each Level 1 digital image for production quality.	3.3.5.1 3.3.5.2 3.3.5.3 3.3.5.4 3.3.5.5
3.1.2.q	The EOSDIS shall collect performance and quality data on each Level 1 digital image generated.	3.3.3.8
3.1.2.r	The EOSDIS shall generate reports and metrics on Level 1 data products produced	3.3.4.1 3.3.4.2
3.1.2.s	The EOSDIS shall provide the capability to produce partial scene L1R or L1G digital images corresponding to the smallest L0R product that can be ordered.	3.1.21 3.3.2.9 3.3.2.10 3.3.3.6 3.3.3.7 4.2.1
	Data Storage Requirements [TBR]	
3.1.3.a	The EOSDIS shall provide the capability to store Level 1R and Level 1G data products for up to 72 hours.	3.3.7.1

ESDIS Requirement	ESDIS Requirement Text	LPGS F&PS Requirements
3.1.3.b	[TBR] The EOSDIS shall provide the capability to allow the filling of an order for Level 1R or Level 1G data products from data products resident in temporary storage.	3.3.7.2
	Data Distribution Requirements	
3.1.4.a	The EOSDIS shall provide the capability to distribute at least 25 Level 1R and Level 1G equivalent WRS scene data products per day to the requesters. (NOTE: These 25 will be included as part of the current 100 L0R scenes per day. Will require a change to ECS rqmts which are Landsat 7 L0R product specific).	ECS
3.1.4.b	The EOSDIS shall package and deliver performance and quality data with each Level 1R and 1G data product.	3.3.4.3
3.1.4.c	The EOSDIS shall package with Level 1R and 1G data products all related data necessary to interpret those Level 1R and 1G data products.	3.3.4.3
3.1.4.d	The EOSDIS shall collect and send radiometric characterization data to the IAS.	3.2.3
	Communications Requirements	
3.1.5.a	The EOSDIS shall provide networking and communications services in support of Level 1 processing.	ECS
	Operations Requirements	
3.1.6.a	The EOSDIS shall provide the capability to reprocess up to 10% of a days data on a daily basis.	4.1.1
3.1.6.b	The EOSDIS shall monitor system performance and data quality.	3.3.8.1 3.3.8.2 3.3.8.3 3.3.8.4 3.3.8.5 3.3.8.6 3.3.8.8 3.1.5 3.1.6 3.1.7 3.1.8 3.3.6.3 3.3.6.4
3.1.6.c	The EOSDIS shall provide user access to information management services for data search, ordering, and order status.	ECS
3.1.6.d	The EOSDIS shall provide Level 1 processing for a minimum of 5 years.	3.1.12
3.1.6.e	The EOSDIS shall provide the capability for expansion of the capabilities and volume of the Level 1 product generation functions.	3.1.20

ESDIS Requirement	ESDIS Requirement Text	LPGS F&PS Requirements
Integration and Test Requirements		
3.1.7.a	The EOSDIS shall provide the capability to incorporate new algorithms and software to improve the radiometric and geometric characteristics of Level 1 data products.	3.1.18
3.1.7.b	The EOSDIS shall be able to revalidate Level 1 processing capabilities whenever an upgrade/ enhancement is made.	3.1.9 3.1.13 3.1.14
3.1.7.c	The EOSDIS shall maintain test data sets and be able to repeat tests to assure compliance with ESDIS Landsat 7 Level 1 processing requirements.	3.1.13 3.1.14
Interface Requirements		
3.1.8.a	The EOSDIS Level 1 processing functions shall comply with the requirements contained in the EOSDIS Core System (ECS) to Landsat 7 System IRD (see Reference TBD).	3.2.1 3.2.2 3.3.1 3.3.1.1 3.3.1.2 3.3.1.3 3.3.6.2
3.1.8.b	The EOSDIS Level 1 processing functions shall comply with the interface specifications contained in the EOSDIS Core System (ECS) to Landsat 7 System ICD (see Reference TBD).	3.2.3 3.2.4

APPENDIX B—ACRONYMS

CPF   calibration parameter file

DHF   Data Handling Facility

ECS   EOSDIS Core System

EDC   EROS Data Center

EDC DAAC   EROS Data Center Distributed Active Archive Center

EGS   ESDIS Ground System

EOS   Earth Observing System

EOSDIS   EOS Data and Information System

EROS   Earth Resources Observation System

ESDIS   Earth Sciences Data and Information System

ETM+   Enhanced Thematic Mapper Plus

FAST   Fast Argonne System for Transport

F&PRS   Functional and Performance Requirements Specification

FIFO   first in-first out

GCP   Ground Control Point

GeoTIFF   Geographic Tag(ged) Image File Format

GSFC   Goddard Space Flight Center

IAS   Image Assessment System

ICD   interface control document

HDF   hierarchical data format

LGS   Landsat 7 Ground Station

L0R   Level 0 Uncorrected Product

LPGS   Level 1 Product Generation System

LPS   Landsat 7 Processing System

L1R   Level 1 Radiometrically Corrected Product

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L1G	Level 1 Geometrically Corrected Product
MOC	Mission Operations Center
MO&DSD	Mission Operations and Data Systems Directorate
MO&SDD	Mission Operations and Systems Development Division
MSCD	Mirror scan correction data
MTF	Modulation Transfer Function
MTPE	Mission to Planet Earth
MTTR	mean time to restore
PCD	Payload Correction Data
PSO	Project Science Office
SRR	system requirements review
TBR	to be reviewed
TBS	to be supplied
TBD	to be determined
UTM	Universal Transverse Mercator
WRS	Worldwide Reference System

Appendix C—Glossary

0R—The stage in the processing prior to radiometric or geometric correction of an image and after the pixels have been placed in detector spatial order.

L0R Product—Products distributed by the ECS to include all bands: 0R image data, metadata, radiometric internal calibration data, calibration parameter file (CPF), payload correction data (PCD), and mirror scan correction data (MSCD).

L1R—The stage in the processing after radiometric correction has been applied to an image and geometric coefficients are appended but not applied.

L1G—The final stage in the processing after radiometric and geometric corrections have been applied to the image data.

Ancillary Data—Spacecraft attitude and ephemeris, radiometric correction coefficients, geometric processing parameters, and image quality statistics.

Archive—Offline storage of data, software and documentation.

Calibration Activities—Recalculating of the radiometric correction coefficients or geometric processing parameters.

Data Storage—Online storage of data accessible to the various functions within the LPGS

ETM+ Equivalent Scene:

> L0R Image Data: $(6320+225) \times 5984 \times 6 + ((12640 + 450) \times 11968) + ((3160 + 113) \times 2992 \times 2) = .41$ GB

> Level 1G, non-rotated, resampled to 25m (except Pan to 12.5m)

>> 220km $\times 170$km$/(.025$km$/$pix$)^2 \times 2$bytes$/$pix $\times 7$ bands $+$

>> 220km $\times 170$km$/(.0125$km$/$pix$)^2 \times 2$bytes$/$pix $= 1.3$ GB

Geodetic Accuracy—The accuracy relative to the geodetic reference surface, the earth ellipsoid.

Geometric Accuracy—The measure of internal distortion of an image.

Geometric Artifacts—Assessment of geometric artifacts (or assessment of geometric accuracy); includes visual assessment of discontinuities of linear features, scale distortion, panoramic distortion, and any other distortions.

Geometric Processing Parameters—Orbit parameters, instrument and alignment parameters, focal plane band locations, scan mirror profile coefficients (along scan and across scan), odd detector sample shifts, alignment matrixes, ADS calibration parameters, gyro calibration parameters, along scan focal plane detector offsets, temperature calibration coefficients, inoperable modes, resampling coefficients, MTF coefficients, and MTF compensation.

HDF-EOS—Self describing, computer comprehensible data products format that fully complies with standard HDF. All information needed for comprehension is contained in the HDF-EOS standard and is encapsulated in an HDF-EOS subroutine library.

Inoperable Detectors—Detectors meeting the following criteria shall be declared inoperable:

a. The quantized digital number (DN) is below 50% of the full scale DN value when a detector is exposed to the ETM+ minimum saturation levels.

b. The quantized digital number (DN) reaches full scale while the input radiance is at or below 0.70 times the ETM+ minimum saturation levels.) The signal-to-noise ratio (SNR) performance degrades to 50% or below the specified ETM+ minimum SNR values.

Level 0R Scene Product—See L0R product.

Level 1 Processing Information—Level 1 product accounting information, product status information, and characterization results from Level 1 processing.

Level 1G Digital Image—Image data that has been both radiometrically and geometrically corrected .

Level 1R Digital Image—Image data that has been radiometrically corrected

Payload Correction Data (PCD)—The PCD contains all data required by ground stations to geometrically correct ETM+ sensor data and redundantly provides the ETM+ imaging configuration. The PCD is embedded in every wideband data virtual channel data unit (VCDU) at a rate of four bytes of PCD per VCDU. PCD data items are as follows:

(1) Angular Displacement Sensor (ADS)

(2) ADS Temperature

(3) Gyro Data

(4) Gyro Drift Data

(5) Attitude Estimate

(6) Time of Last SV Clock Update

(7) SV Time Drift Characterization Data

(8) Ephemeris

(9) ETM+ Telemetry Data

(10) Spacecraft ID and Time Code

(11) Multiplexer Status

(12) PDF A/D Ground Reference

(13) Minor Frame Sync

(14) Major Frame Identification

(15) Spacecraft Identifier

(16) Attitude Control System Mode

(17) ETM+ On/Off Times.

Radiometric Image Artifacts—Striping, banding, scan correlated shift, bright target recovery response (memory effect), coherent noise, impulse noise, detector saturation, and detector inoperability.